August 20, 2019

ENTECH
ENGINEERING, INC.

505 ELKTON DRIVE
COLORADO SPRINGS, CO 80907
PHONE (719) 531-5599
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Classic Communities
6385 Corporate Drive, Suite 200
Colorado Springs, Colorado 80919

Attn: Mark Sherwood

Re: Pavement Recommendations
Forest Lakes, Filing No. 4
El Paso County, Colorado

Dear Mr. Sherwood:

As requested, Entech Engineering, Inc. has obtained samples of the pavement subgrade soils from the southern portion of Long Valley Drive in the Forest Lakes Filing No. 4 subdivision. This letter presents the results of the laboratory testing and pavement recommendations for the roadway section identified in this document. This letter should be used in conjunction with the Pavement Recommendations drilled within other roadways in this filing dated July 9, 2018, Entech Job No. 181096. The approximate test boring locations and laboratory testing results summary from this and the previous investigation are included in this document.

Project Description:

The roadway for this project consists of the southern section of Long Valley Drive, south of the intersection of Lakes Edge Drive, in the Forest Lakes Filing No. 4. Subdivision in El Paso County, Colorado. Subsurface Soil Investigation and laboratory testing was performed to determine the pavement support characteristics of the soils. The approximate locations of the test borings are presented in the Test Boring Location Plan Figure 1.

Subgrade Conditions:

One test boring was drilled for this investigation, Test Boring No. 5, to a depth of 10 feet below the existing ground surface (bgs). Four test borings (Test Boring Nos. 1 through 4) were previously drilled along the roadway sections to depths of 5 and 10 feet bgs. The soils consisted of native silty to clayey sand (Soil Type 1) and silty to clayey sand fill (Soil Type 1A). The Test Boring Log for Test Boring No. 5 is presented in Appendix A. Sieve Analysis and Atterberg Limits testing were performed on the soil samples obtained from the test borings for the purpose of classification. The percent passing the No. 200 sieve for the soils at subgrade depths ranged from approximately 21 to 32 percent. The subgrade soils classify as A-2-4 and A-2-6 (AASHTO) for the sand soils which have good pavement support characteristics. Based on the classification testing results, one soil type was determined. Groundwater was not encountered in the test borings.

Swell/Consolidation testing was required on the subgrade soil based on the AASHTO Classification. A sample of clayey sand fill tested resulted in a consolidation of 0.1 percent under a 150 psf surcharge Mitigation for expansive soils is not required on this portion of roadway. Laboratory test results are presented in Appendix B and are summarized in Table 1.

Construction documents
approved with filing 2B
filed in both files.

SF 18-017

Due to the similarities of the subgrade soil types from this investigation and the previous investigation, the California Bearing Ratio (CBR) data was used for this short section of roadway. The previous findings are as follows: California Bearing Ratio (CBR) testing was performed on a representative sample of Soil Type 1A to determine the support characteristics of the subgrade soils for the roadway sections. The results of the CBR testing is presented in Appendix B and summarized as follows:

CBR No. 1
Soil Type 1A – Silty Clayey Sand Fill

R @ 90% = 55
R @ 95% = 73
Use R = 50 for Design

Classification Testing

Liquid Limit	19
Plasticity Index	6
Percent Passing 200	31.0
AASHTO Classification	A-2-4
Group Index	0
Unified Soils Classification	SC-SM

Pavement Design

CBR testing was used to determine pavement sections for the roadway sections. Pavement sections were determined utilizing El Paso County Engineering Criteria and Report Manual. The roadways classily as Urban Local Low Volume roads which uses an 18K ESAL value of 36,500 for design purposes. Alternative pavement sections were determined for full depth asphalt, asphalt supported on basecourse, and asphalt on cement stabilized subgrade.

Design parameters used in the pavement analysis for the roadways are as follows:

Reliability	80%
Standard Deviation	0.44
Resilient Modulus	13,168 psi
"R" Value Subgrade	50.0
Serviceability Index	2.5
Hot Bituminous Pavement	0.44
Basecourse	0.11
Cement Stabilized Subgrade	0.12

The pavement design calculations are presented in Appendix C. Pavement section alternatives for the roadway section is presented as follows. Any additional grading may result in subgrade soils with different support characteristics. The following pavement sections should be re-evaluated if additional grading is performed.

Pavement Sections – S. Long Valley Drive
Urban Local Low Volume Road
Soil Type 1A & 1

Alternative	Asphalt	Basecourse (in.)	Cement Stabilized Subgrade (in.)
1. Asphalt Over Basecourse	3.0*	4.0*	
2. Full Depth Asphalt	5.0[1]*		
3. Asphalt Over Stabilized Subgrade	4.0		10.0

[1] Full depth sections are only allowed over chemically treated or suitable subgrade. Currently full depth sections are not allowed in El Paso County.
* Minimum sections required per the El Paso County Engineering Criteria Manual.

Roadway Construction - Full Depth Asphalt and Asphalt on Aggregate Basecourse Alternatives

Prior to placement of the asphalt, the subgrade should be proofrolled and compacted to a minimum of 95 percent of its maximum Modified Proctor Dry Density, ASTM D-1557 at ±2 percent of optimum moisture content. Any loose areas should be removed and replaced with suitable materials. Base course materials should be compacted to a minimum of 95 percent of its maximum Modified Proctor Dry Density, ASTM D-1557 at ± 2 percent of optimum moisture content. Special attention should be given to areas adjacent to manholes, inlet structures and valves.

Roadway Construction — Cement Stabilized Subgrade Alternative

Prior to placement of the asphalt, the subgrade shall be stabilized by addition of cement to a depth of 10 inches. All of the residential streets will use a 4-inch asphalt layer on a 10-inch cement treated subgrade layer. The amount of cement applied shall be 2 percent (by weight) of the subgrades maximum dry density as determined by the Modified Proctor Test (ASTM D-1557) based on cement stabilization testing. The cement should be spread evenly on the subgrade surface and be thoroughly mixed into the subgrade over a 10-inch depth such that a uniform blend of soil and cement is achieved. Prior to application or mixing of the cement, the upper 10 inches of subgrade should be thoroughly moisture conditioned to the soil's optimum water content or as much as 2 percent more than the optimum water content as necessary to provide a compactable soil condition. Densification of the cement-stabilized subgrade should be completed to obtain a compaction of at least 95 percent of the subgrade maximum dry density as determined by the Modified Proctor Test (ASTM D-1557). Satisfactory compaction of the subgrade shall occur within 90 minutes from the time of mixing the cement into the subgrade.

The following conditions shall be observed as part of the subgrade stabilization:

- Type 1/11 cement as supplied, a local supplier shall be used. All cement used for stabilization should come from the same source. If cement sources are changed a new laboratory mix design should be completed.

- Moisture conditioning of the subgrade and/or mixing of the cement into the subgrade shall not occur when soil temperatures are below 40^0 F. Cement treated subgrades should be maintained at a temperature of 40^0 F or greater until the subgrade has been compacted as required.

- Cement placement, cement mixing and compaction of the cement treated subgrade should be observed by a Soils Engineer. The Soils Engineer should complete in situ compaction tests and construct representative compacted specimens of the treated subgrade material for subsequent laboratory quality assurance testing.

In addition to the above guidance the asphalt, subgrade conditions, cement, compaction of materials and roadway construction methods shall meet the El Paso County specifications.

We trust that this report contains the information you require. If you have questions or need additional information, please contact us.

Respectfully Submitted,

ENTECH ENGINEERING, INC.

Daniel P. Stegman

COLORADO LICENSED
MARK HOWARD HAUSCHILD
35140
8/27/19
PROFESSIONAL ENGINEER

Reviewed by:

Mark H. Hauschild, P.E.
Senior Engineer

DPS/sc

Entech Job No. 181096
AAprojects/2018/181096/181096 pr_F4

TABLE

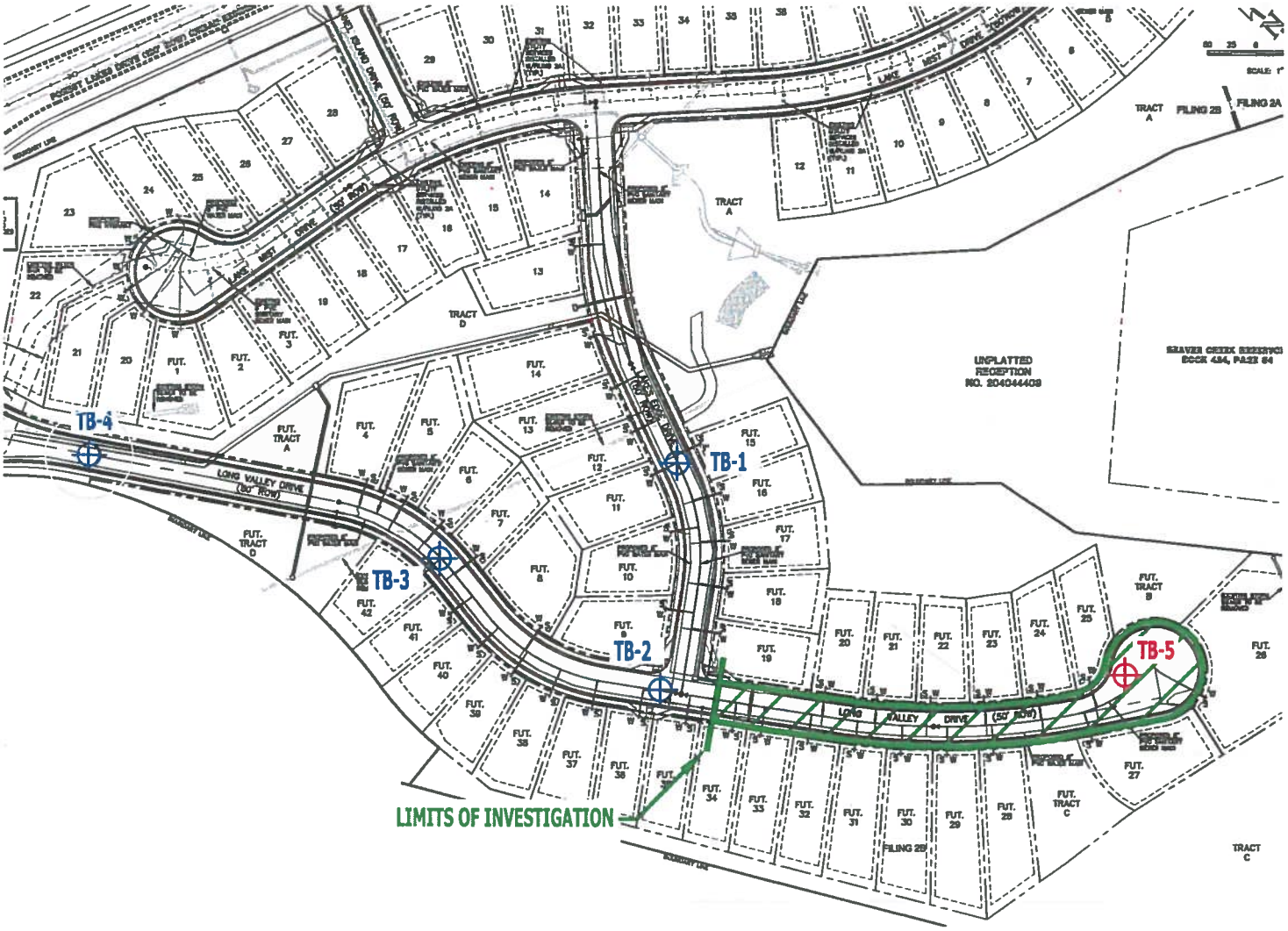
TABLE 1

SUMMARY OF LABORATORY TEST RESULTS

CLIENT CLASSIC COMMUNITIES
PROJECT FOREST LAKES, F-4
JOB NO. 181096

SOIL TYPE	TEST BORING NO.	DEPTH (FT)	WATER (%)	DRY DENSITY (PCF)	PASSING NO. 200 SIEVE (%)	LIQUID LIMIT (%)	PLASTIC INDEX (%)	SULFATE (WT %)	AASHTO CLASS.	SWELL/ CONSOL (%)	UNIFIED CLASSIFICATION	SOIL DESCRIPTION
1A, CBR #1	1	0-3			31.0	19	6		A-2-4		SC-SM	FILL, SAND, CLAYEY, SILTY
1A	1	1-2			32.4	23	11	0.01	A-2-6		SC	FILL, SAND, CLAYEY
1A	3	1-2			29.4	24	10		A-2-4		SC	FILL, SAND, CLAYEY
1A	4	1-2			25.9	22	10		A-2-4		SC	FILL, SAND, CLAYEY
1A	5	1-2	13.2	121.6	31.6	35	15		A-2-6	-0.1	SC	FILL, SAND, CLAYEY
1	2	1-2			21.4	22	7		A-2-4		SC-SM	SAND, CLAYEY, SILTY

FIGURE



TB-2 - APPROXIMATE TEST BORING LOCATIONS AND NUMBERS FROM PAVEMENT REPORT DATED JULY 9, 2018, ENTECH JOB NO. 181096

TB-5 - APPROXIMATE TEST BORING LOCATION AND NUMBER

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TEST BORING LOCATION PLAN
FOREST LAKES, FILING 4
COLORADO SPRINGS, CO
FOR: CLASSIC COMMUNITIES

DRAWN BY:	DATE DRAWN:	DESIGNED BY:	CHECKED:
SC	08/20/19	SC	SC

JOB NO.: 181096

FIG. NO.: 1

APPENDIX A: Test Boring Logs

TEST BORING NO. 5
DATE DRILLED 8/13/2019
Job # 181096

TEST BORING NO.
DATE DRILLED
CLIENT CLASSIC COMMUNITIES
LOCATION FOREST LAKES, F-4

REMARKS

DRY TO 10', 8/13/19

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type	Description
			18	14.6	1A	FILL 0-10', SANDY, CLAYEY, FINE TO MEDIUM GRAINED, BROWN, MEDIUM DENSE TO LOOSE, MOIST
5			19	16.0	1A	
10			5	5.6	1A	
15						
20						

REMARKS

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
5					
10					
15					
20					

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COLORADO SPRINGS, COLORADO 80907

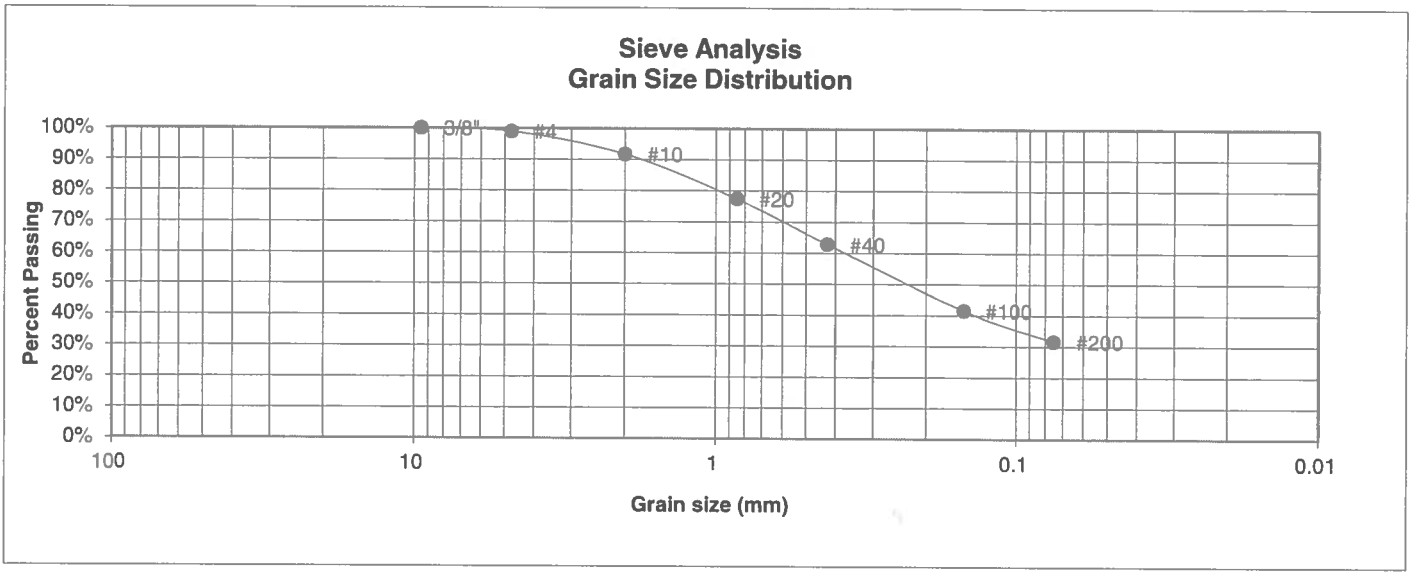
TEST BORING LOG

DRAWN:	DATE:	CHECKED:	DATE:
		SCC	8/20/19

JOB NO.: 181096
FIG NO.: A-1

APPENDIX B: Laboratory Test Results

UNIFIED CLASSIFICATION	SC	CLIENT	CLASSIC COMMUNITIES
SOIL TYPE #	1A	PROJECT	FOREST LAKES, F-4
TEST BORING #	5	JOB NO.	181096
DEPTH (FT)	1-2	TEST BY	BL
AASHTO CLASSIFICATION	A-2-6	GROUP INDEX	1



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	99.0%
10	91.7%
20	77.4%
40	62.8%
100	41.5%
200	31.6%

Atterberg Limits	
Plastic Limit	20
Liquid Limit	35
Plastic Index	15

Swell	
Moisture at start	
Moisture at finish	
Moisture increase	
Initial dry density (pcf)	
Swell (psf)	

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LABORATORY TEST RESULTS

DRAWN:	DATE:	CHECKED:	DATE:
		SCC	8/20/19

JOB NO.: 181096
FIG NO.: B-1

CONSOLIDATION TEST RESULTS

TEST BORING #	5	DEPTH(ft)	1-2
DESCRIPTION	SC	SOIL TYPE	1A
NATURAL UNIT DRY WEIGHT (PCF)			122
NATURAL MOISTURE CONTENT			13.2%
SWELL/CONSOLIDATION (%)			-0.1%

JOB NO. 181096
CLIENT CLASSIC COMMUNITIES
PROJECT FOREST LAKES, F-4

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SWELL CONSOLIDATION
TEST RESULTS

DRAWN:	DATE:	CHECKED:	DATE:
		SCC	8/20/19

JOB NO.: 181096
FIG NO.: B-2

APPENDIX C: Pavement Design Calculations

FLEXIBLE PAVEMENT DESIGN

DESIGN DATA — CLASSIC COMMUNITIES
FOREST LAKES FILING 4 - SOUTH PORTION OF LONG VALLEY DRIVE

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL (W_{18}) =	36,500
Hveem Stabilometer (R Value) Results:	R =	50
Standard Deviation	S_o =	0.44
Loss in Serviceability	Δpsi =	2.5
Reliability	Reliability =	80
Reliability (z-statistic)	Z_R =	-0.84
Soil Resilient Modulus	M_R =	13168

Weighted Structural Number (WSN): → WSN = 1.45

DESIGN TABLES AND EQUATIONS

$S_1 = [(R - 5) / 11.29] + 3$

$M_R = 10^{[(S_1 + 18.72) / 6.24]}$

$M_R = 2555 * CBR^{0.64}$

$k = M_R / 19.4$

Where:

M_R = resilient modulus (psi)

S_1 = the soil support value

R = R-value obtained from the Hveem stabilometer

CBR = California Bearing Ratio

Reliability (%)	Z_R (z-statistic)
80	-0.84
85	-1.04
90	-1.28
93	-1.48
94	-1.56
95	-1.65
96	-1.75
97	-1.88
98	-2.05
99	-2.33
99.9	-3.09
99.99	-3.75

$$\log_{10}W_{18} = Z_R * S_O + 9.36*\log_{10}(SN+1) - 0.20 + \frac{\log_{10}\left[\frac{\Delta PSI}{4.2 - 1.5}\right]}{0.40 + \frac{1094}{(SN+1)^{5.19}}} + 2.32*\log_{10}M_R - 8.07$$

Left	Right	Difference
4.56	4.56	0.0

Job No. 181096
Fig. No. C-1

DESIGN CALCULATIONS

DESIGN DATA CLASSIC COMMUNITIES
FOREST LAKES FILING 4 - SOUTH PORTION OF LONG VALLEY

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL =	36,500
Hveem Stabilometer (R Value) Results:	R =	50
Weighted Structural Number (WSN):	WSN =	1.45

DESIGN EQUATION

$$WSN = C_1D_1 + C_2D_2$$

C_1 = 0.44 Strength Coefficient - Hot Bituminous Asphalt
C_2 = 0.11 Strength Coefficient - Aggregate Basecourse

D_1 = Depth of Asphalt (inches)
D_2 = Depth of Basecourse (inches)

FOR FULL DEPTH ASPHALT SECTION

$D_1 = (WSN)/C_1$ = 3.3 inches of Full Depth Asphalt
Use 5.0 inches Full Depth

FOR ASPHALT + AGGREGATE BASECOURSE SECTION

Asphalt Thickness (t) = 3.0 inches
$D_2 = ((WSN) - (t)(C_1))/C_2$ = 1.2 inches of Aggregate
Basecourse, use 4.0 inches

RECOMMENDED ALTERNATIVES

1. 3.0 inches of Asphalt + 4.0 inches of Aggregate Basecourse, or
2. 5.0 inches of Asphalt

Job No. 181096
Fig. No. C-2

DESIGN CALCULATIONS

DESIGN DATA: CLASSIC COMMUNITIES
FOREST LAKES FILING 4 - SOUTH PORTION OF LONG VALLEY DRIVE
CEMENT TREATED SECTIONS - URBAN LOCAL LOW VOLUME

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL =	36,500
Hveem Stabilometer (R Value) Results:	R =	50
Weighted Structural Number (WSN):	WSN =	1.45

DESIGN EQUATION

$$WSN = C_1D_1 + C_2D_2$$

C_1 = 0.44 Strength Coefficient - Hot Bituminous Asphalt
C_2 = 0.12 Strength Coefficient - Cement Treated Subgrade.

D_1 = Depth of Asphalt (inches)
D_2 = Depth of Cement Treated Subgrade (inches)

FOR FULL DEPTH ASPHALT SECTION - (CURRENTLY NOT ALLOWED)

$D_1 = (WSN)/C_1$ = 3.3 inches of Full Depth Asphalt
Use 5.0 inches Full Depth

FOR ASPHALT + CEMENT TREATED SUBGRADE SECTION

Asphalt Thickness (t) = 4.0 inches
$D_2 = ((WSN) - (t)(C_1))/C_2$ = -2.6 inches
Use 10.0 inches of Cement Treated Subgrade.

RECOMMENDED ALTERNATIVES

1. 4.0 inches of Asphalt + 10 inches of Cement Treated Subgrade.
2. 5.0 inches of Full Depth Asphalt

Job No. 181096
Fig. No. C-3